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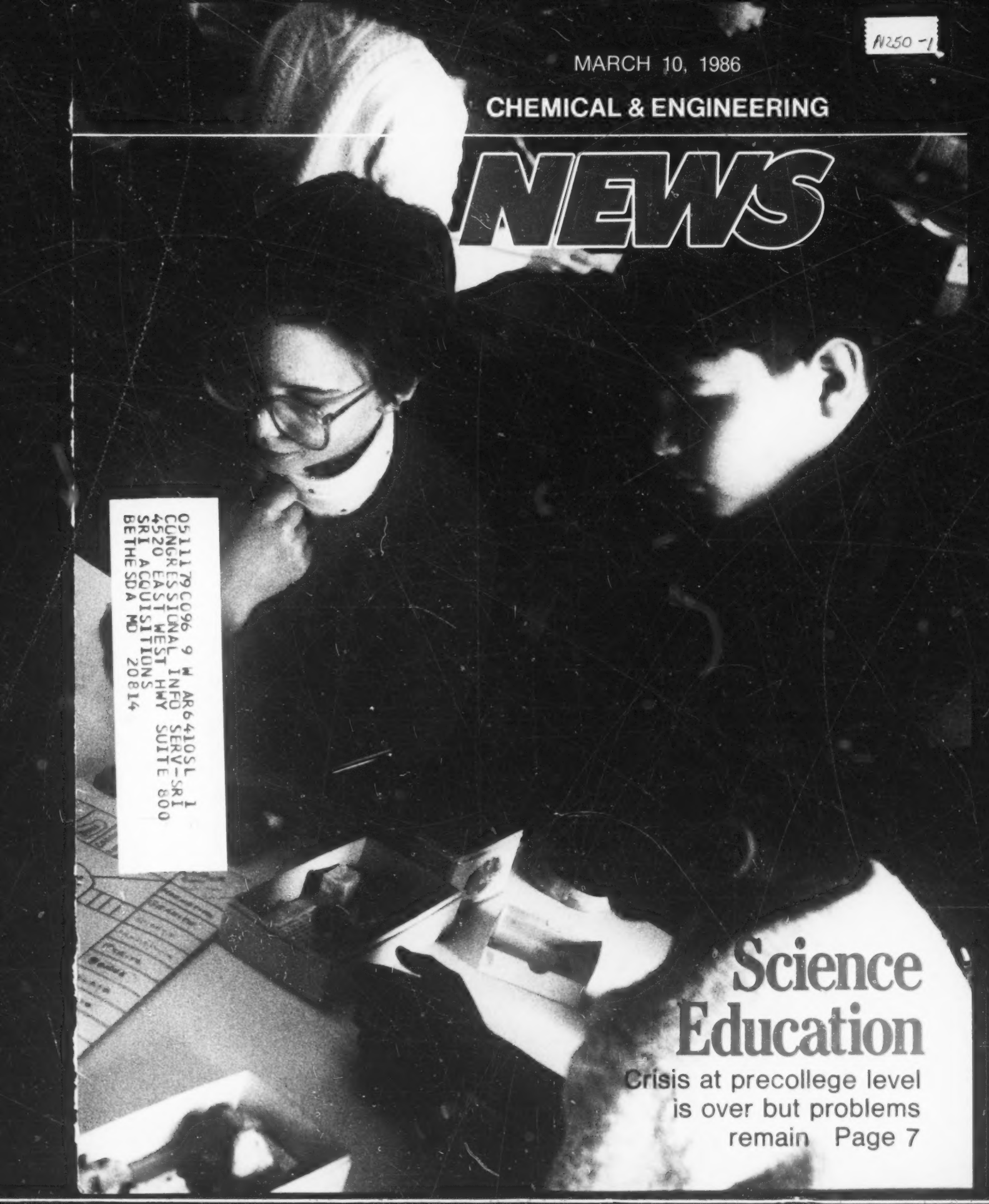
MARCH 10, 1986

CHEMICAL & ENGINEERING

# NEWS



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## Science Education

Crisis at precollege level is over but problems remain Page 7

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NEWS

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## News Focus

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# Crisis Passes but Problems Remain For Precollege Science and Math

## Dedicated individuals and groups are plugging away at the problems, not just to do a patch job, but to establish a rational national structure for such education at all precollege levels

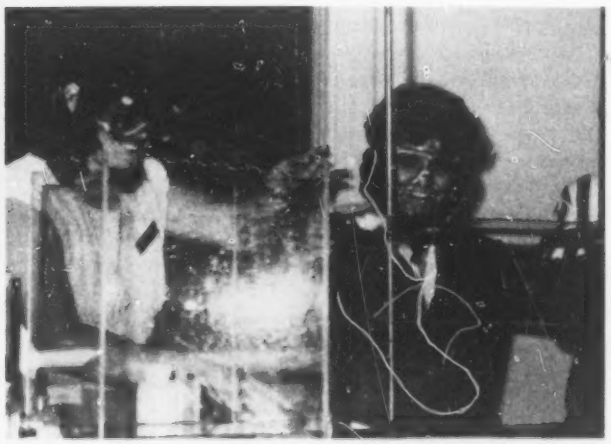
**Ward Worthy,** C&EN Chicago

The crisis in precollege science and mathematics education—so much in the news just four years ago—is over.

No, the problems that provoked the crisis haven't been solved. There've been a few changes for the better, but there's still plenty wrong with the way the U.S. goes about the job of teaching science and math to its kindergarten-through-12th-grade students. Nevertheless, the crisis, as measured by the benchmarks of political and media attention, has vanished.

Public concern over the crisis in precollege science and math education reached its loudest postsputnik expression in 1982. Meetings were called, speeches delivered, articles published (C&EN, July 19, 1982, page 9, for example). It was an exciting time. Study commissions were formed. Recommendations were made. A little money was dredged up from here and there. A few programs got under way. The public has a short attention span, however. The excitement soon died down. What was a clamor in 1982 has diminished to a murmur in 1986.

Crisis past, problems remain. Was all in vain? No. But that's not the right question. A crisis, by definition, doesn't drag on. A crisis (the dictionary says) is "a decisive moment" or, for a patient with a serious illness, "a turning point for better or worse." The disease that afflicts precollege science and math education had festered for years before "the patient"



*High school teacher participants at Institute for Chemical Education summer workshops for chemistry teachers: (left) Tanya L. Phillips in 1984, and (above, from left) Rose McBryan and Maria Dalhoumi last year*

went on the critical list in 1982. Overnight recovery was not to be expected.

The question to ask, then, is not, "Has the patient been restored to good health?" but rather, "Has the patient taken a turn for the better or a turn for the worse?"

The evidence, on balance, suggests a turn for the better. It's not so much the numbers—test scores, education budgets, and such. So far, with few exceptions, the postcrisis numbers don't yet look all that much better than the precrisis numbers. However, even though the crisis atmosphere has passed, many dedicated individuals and groups are still plugging away at the problems. Encouragingly, the approach hasn't been just to do a patch job. Instead, the aim has been to establish a rational national structure for science and math education at all precollege levels.

In addition, one senses changes in climate and attitudes that bode well for the future. The scientific research community now seems more aware that the edifice of science can be no stronger than the foundation it's built upon. Consequently, science education is finally getting a little respect. The relationships between researchers and science teachers aren't quite so "us" and "them" as they used to be. Scientific societies are admitting out loud that they share the responsibility for the way that science and mathematics are taught in the public schools. Industries are expanding their support of education to include elementary and secondary schools.

What has happened in the past four years gains perspective from a brief examination of the problems that brought precollege science and math education to its 1982 crisis.

For one thing, it had become obvious that students were taking fewer science and mathematics courses than they had in former years. Also, mean scores on standard tests such as the Scholastic Achievement Test (SAT) had declined. Mean math scores, for example, dropped from 502 (out of a possible 800) in 1963 to 466 in 1980. Other measures, such as national assessments of science achievement, similarly showed declines from earlier years. A number of "international comparison" studies were made in the early 1980s. These almost uniformly alleged that U.S. students weren't doing nearly so well in science and math as their counterparts in more authoritarian parts of the world such as the U.S.S.R., Japan, and China.

According to various other surveys of the precollege scene, there were serious or critical shortages of chemistry, physics, and mathematics teachers in many states. In 1981, for example, more than half the newly hired science and math teachers were unqualified to teach their subjects, but had been hired on an emergency basis because no qualified teachers could be found. The teachers that were qualified were an aging and decreasing group. Many were demoralized by low pay, poor working conditions, and lack of support. And they were tired of getting blamed for things over which they really had no control.

Not surprisingly, few students were choosing careers as public school science or math teachers, and even fewer of the best and brightest were choosing such careers. Furthermore, university education departments were often preoccupied with turning out elementary school teachers and school administrators; responsibility for training the more discipline-oriented science and math teachers was hard to pin down.

Meanwhile, National Science Foundation support of science education, as a proportion of its total budget, had been declining fairly steadily over the years, from about 46% in fiscal 1959 to about 2% in fiscal 1982. Support for precollege science education had fared even worse, falling from 34% of the total NSF budget in 1959 to practically nothing in fiscal 1982.

That may well have been the turning point. In fact, the National Science Board (NSF's policy-making body) had already, in 1981, appointed a Commission on Precollege Education in Science, Mathematics & Technology, and had charged its members to "define a national agenda" and "develop an action plan" to address the problems in that area. The National Academy of Sciences had put the issues into even sharper focus with its May 1982 convocation on the subject (C&EN, May 24, 1982, page 39). It can be argued, however, that the NSF move to eliminate precollege support was the "Thanks, I needed that!" slap in the face that made a lot of people aware that a crisis was at hand and that something had to be done.

Indeed, a flurry of activity followed that 1982 NAS convocation. In 1983, the NSB commission presented its plan of action, "Educating Americans for the 21st Century." In a nutshell, the commission said that there should be more precollege science and math education and that it should be better (C&EN, Sept.

**Teacher shortages worst for high school physics, elementary science and math**

| Fields | Shortage per 1000 teachers | Noncertified as % of all in field |
|---|---|---|
| **ALL LEVELS** | | |
| All fields | 1.6 | 3.5% |
| All science fields | 1.7 | 4.1 |
| Biology | 1.7 | 3.8 |
| Chemistry | 1.9 | 4.1 |
| Physics | 4.5 | 5.6 |
| Other sciences | 1.4 | 4.0 |
| Mathematics | 1.8 | 4.1 |
| **SECONDARY LEVEL** | | |
| All fields | 1.5 | 3.3 |
| All science fields | 1.4 | 4.1 |
| Biology | 1.7 | 3.8 |
| Chemistry | 1.9 | 4.1 |
| Physics | 4.5 | 5.6 |
| Other sciences | 0.8 | 4.0 |
| Mathematics | 1.4 | 4.1 |
| **ELEMENTARY LEVEL** | | |
| All fields | 1.6 | 3.6 |
| General science | 3.9 | 4.0 |
| Mathematics | 4.1 | 4.2 |

Note: Data for 1984. Source: National Center for Educational Statistics

26, 1983, page 16). The commission also spelled out detailed recommendations as to how this should be accomplished by 1995. It also pegged the first-year costs of the program at more than $1.5 billion—and that was just the federal portion.

The American Chemical Society appointed a task force in 1983 to make an overall examination of the state of chemical education in the U.S. and to make appropriate recommendations. The task force, chaired by Peter E. Yankwich of the University of Illinois, made its report in the fall of 1984. The 70-page report, whose numerous recommendations are not easily summarized, did reflect the importance attached to the teaching of science in elementary schools.

*Chemistry professor Henry A. Bent of North Carolina State University carries out demonstration at ICE summer workshop*

Actions, however, not recommendations, are what solve problems. And as might be expected, the actions to date have lagged far behind the recommendations. Just the same, some things have changed.

Consider, for example, the complaint that precollege students were taking fewer science and math courses. One of the main reasons for that phenomenon was that they didn't have to take the courses at all. In the 1960s and early 1970s, school boards and other standards-setting groups reacted to the public sentiment of the times by reducing the requirements for graduation from high school as well as for admission to colleges and universities. Lately—again in reaction to public sentiment—these same groups have been moving to raise the standards again.

Even though education is still largely a local affair in the U.S., and requirements vary widely among the states, between 1980 and 1985, 30 states and the District of Columbia increased their minimum requirements for mathematics courses by at least one year. Similarly, 24 states and D.C. added at least a year's worth of science courses to their graduation requirements. Also, seven states that formerly left such matters to local boards of education since have imposed state minimums for science and math, along with other subjects.

At the same time, standard test scores, after having declined for years, have started to inch upward again. "But that's to be expected," says one observer of the education scene. "The crisis was quantified in terms of test scores. Principals' jobs were on the line. They'll admit, privately, that the word has gone out: Teach to maximize the scores."

As to the shortage of competent science and math teachers, it depends on whose numbers are looked at and whose are believed. According to head-count figures for 1984 from the National Center for Education Statistics, for example, the only really serious shortages were of high school physics teachers and elementary teachers of science and math. The proportion of noncertified teachers in those fields was a little higher than the average for all fields, but not startlingly so.

Some observers maintain that those figures are misleading, however. "There's no shortage of teachers, but there's a shortage of competence," says Bill G. Aldridge, executive director of the National Science Teachers Association. "Because of increased requirements, math and science enrollments are going up even as the general school population is declining. The overall decline produces a surplus of teachers. I'm talking, for example, about that physical education teacher they don't want to fire, so they reassign him to teach science. About a third of the classes in science are being staffed that way now."

Things will get even worse in that respect, according to Rand Corp. social scientist Linda Darling-Hammond. Enrollments in elementary and secondary schools have been declining for a decade, she says, but an early 1980s "baby boomlet" soon will cause enrollments to increase again. At the same time, the college-age population from which most teachers are drawn will continue to decline. By 1988, the number of new teachers may supply only 80% of the demand.

Meanwhile, Darling-Hammond says, "the current highly educated and experienced staff is dwindling" as a result of retirement by older teachers and desertion by younger ones. Unless reforms are made, she adds, the teacher shortage will be so critical in a few years that the least academically qualified students will become "the tenured teaching force for the next two generations of American school children."

In all this gloom about future teacher shortages, there is one bright spot. One potential source of new

science and math teachers is the pool of middle-aged scientists and other quantitatively trained persons from industry or government who have chosen early retirement—or who have had it thrust upon them. Many of these people have expressed interest in second careers as teachers. Several programs to help prepare them for such careers are under way or planned.

The idea makes sense. There are a lot of talented people of all ages who would make good teachers, and who would like to be teachers. But the young ones, with futures to think of, often feel that they can't afford to take low-paying jobs with limited opportunities for advancement. The midcareer people, in contrast, with their children grown, with their mortgages paid down, and with some retirement income coming in, can afford the luxury of being teachers.

"Individuals give varied reasons for wanting to become classroom teachers at midcareer," says Katherine K. Merseth, director of the Harvard Graduate School of Education's midcareer math and science program. "Many come seeking a change in the quality of their lives and an opportunity to contribute to the education of young people."

Merseth notes that the Harvard program began in fall 1983 with a class of seven students and expanded to 20 students in 1984. The number of participants is limited, she says, "because those in midcareer need specific support and assistance in making this transition." Although 20 is a small number in the face of the shortage, she adds, the program serves as a model for other schools. The University of Vermont and Washington University (St. Louis) already have similar programs and others are being planned.

For example, Purdue University has just revealed the details of its new program designed specifically to lead to certification for midcareer scientists who want to teach in Indiana secondary schools (C&EN, March 3, page 32). The first class is due to begin this fall.

Chemical educator J. Dudley Herron, director of the new program, notes that midcareer scientists have indicated "that they are unwilling to commit long periods of time to prepare to teach." So the Purdue program is designed to meet certification requirements in one academic year.

The program will emphasize practical experience in the classroom, Herron says. Participants will, among other things, observe classes in public schools, help teach introductory college science courses, and work on special projects. The last nine weeks of the program will be spent teaching science under the supervision of an experienced teacher.

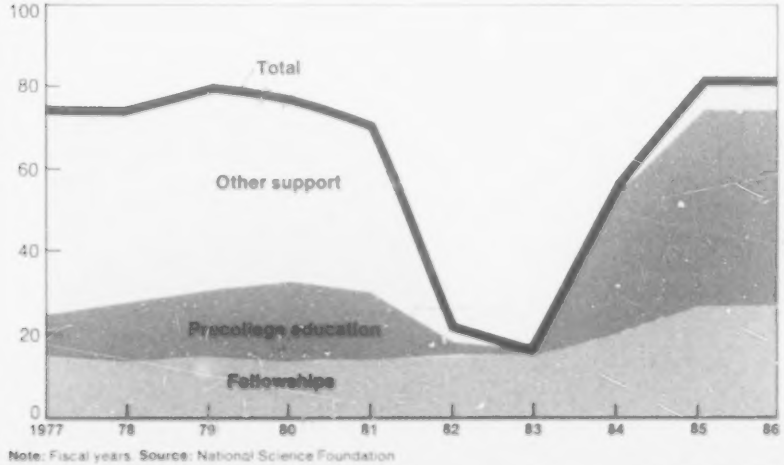
F. James Rutherford, chief education officer of the American Association for the Advancement of Science, comments that only marginal headway has been made so far. "Laws have been passed, curriculums changed, state requirements increased, but nothing much has really happened." One big reason, as usual, is lack of money. "Out of a billion federal dollars promised, only about $45 million has been realized," he says. Much of that, he adds, has gone just to maintain the status quo. Nor is Rutherford optimistic about the future. "People will always say they care about education, and they mean it. But it's something down the road. We haven't yet provided the incentives for real change. We have a long way to go."

Bassam Z. Shakhashiri, head of the National Science Foundation's Science & Engineering Education Directorate (SEED), concurs that there's still a long way to go. Yet, he argues, quite a bit has been accomplished. For one thing, the re-establishment of SEED in October 1983, after its abolition a year earlier, was in itself a large step in the right direction.

Shakhashiri, a University of Wisconsin chemistry professor, has long been well known in chemical education circles as an enthusiastic advocate of precollege science instruction. He was instrumental in establishing the Institute for Chemical Education, which so far has concentrated its efforts on programs for precollege teachers (C&EN, April 9, 1984, page 28).

Not surprisingly, Shakhashiri considers his appointment as "a mandate to focus on precollege programs." Of his total fiscal 1985 budget of $87 million, more than $50 million was earmarked for such programs, with roughly half going for development of new instructional materials and half for training programs for elementary and secondary school teachers. A similar amount is budgeted for fiscal 1986, but Shakhashiri expects a cut of 4.3%, effective March 1, as a result of the Gramm-Rudman-Hollings act. Current plans call for

**More than half of NSF's education budget now goes to precollege programs**




Note: Fiscal years. Source: National Science Foundation

*Fowler (left): generous Carnegie Foundation grant*
*Shakhashiri: involve practitioners with educators*

an $89 million total SEED budget for fiscal 1987, but that amount will almost surely be cut, perhaps 20 or 25%, again as a result of Gramm-Rudman.

When Shakhashiri came to SEED in June 1984, one of his first tasks was to reassemble a qualified staff. The staff now totals 65 and it is, Shakhashiri says, highly qualified. He notes that a high school teacher and an elementary school teacher are among his program officers, but denies that they are in any way tokens. "I hired them for their expertise," he says.

Moreover, the staff includes four people who were on the ACS task force on chemical education: chairman Yankwich, who now serves as SEED's senior executive officer; Jerry A. Bell of Simmons College, who heads the division of teacher preparation and enhancement; associate program director Ethel L. Schultz (a high school teacher from Marblehead, Mass.); and Shakhashiri himself.

Regarding current SEED activities, Shakhashiri says there's a special thrust to improve science and math education at the elementary and middle school levels, noting that these are the critical years in forming attitudes towards those subjects. And because NSF funds are limited, SEED must play a "catalytic role, investing in targeted areas."

In line with that policy, SEED this year has issued targeted program solicitations inviting proposals for grants for programs in three areas: preparing new middle school science and math teachers, developing new materials for elementary school science instruction, and developing new materials for elementary school mathematics instruction. Next year, Shakhashiri says, other high-priority areas will be targeted.

Shakhashiri adds that he would like to deliver one message: "It's very important to involve science practitioners with science educators," he says. In that respect, he adds, he's still a teacher. "But now my students are the NSF people and the people on Capitol Hill who need to know what kinds of programs deserve support."

The rebirth of NSF's education directorate is only one manifestation of renewed and continuing national interest in precollege education. Many other efforts are under way. Most of these efforts, understandably, are intended to furnish quick fixes for acute problems. Others, however, are looking much further ahead.

AAAS's Rutherford points out, for example, that there's no shortage of reports lamenting the shortcomings of science and math education in U.S. schools. However, he says, none of these reports have dealt well with the questions of exactly what students should be learning in those areas.

To provide some answers to those questions, AAAS has launched what it calls Project 2061. That name was chosen because 2061 is the year that Halley's comet will next return to Earth's part of the universe. The idea is to stress the long-term goals of the project. Initial support is being provided by the Carnegie Foundation.

Phase I of the three-phase project sets out to answer the question, "Out of all the possibilities, what science and technology is most worth learning by all young people by the time they leave high school?" Target date for completion is 1987. AAAS notes that the intent is to "provide a foundation that will serve all students" and that no distinctions will be made between college-bound and other students.

Phase II will involve the formulation of recommendations for curricula, teacher training, testing, and school organization, all based on the answers obtained in phase I. "Eventually," AAAS says, "phase III will spearhead the implementation of changes in the schools."

Contrary to the beliefs of those who live there, important things do happen outside of Washington, D.C. Perhaps one of the most significant and gratify-

ing trends to emerge since the crisis has been the springing up of local and regional alliances between schools and businesses, aimed at improving public school education in general and science and math education in particular.

These alliances typically have names like Business/Education Together (California), Partners in Education (Illinois), or Center for the Advancement of Science Education (Wisconsin). It's hard to get an accurate count of just how many such ventures there are. One source document lists more than 50 alliances, but many of these are state or regional agencies that provide coordination and services to a number of local business-education partnerships. The actual number of such local partnerships is probably in the low hundreds.

In addition, an umbrella organization, the Triangle Coalition, has recently been established and is based in Washington, D.C. It describes itself as "a joint council of representatives from business, industry, labor, education, science, and engineering groups that have committed some of their resources to the improvement of science teaching."

Reflecting its joint nature, the coalition has three chairmen: one from education (Mary Futrell, president of the National Education Association), one from industry (Du Pont executive vice president Robert C. Forney), and one from science (University of California, Berkeley, chemistry professor Glenn T. Seaborg). A steering committee of prominent persons from various companies and organizations provides policy guidance. John M. Fowler, special projects officer for the National Science Teachers Association, acts as staff director.

The Triangle Coalition is funded by assessments on its member organizations (there are currently about 40 members; ACS is one of them) and by grants from other sources. Fowler notes, for example, that a "generous" two-year, $250,000 grant by the Carnegie Foundation has just been approved.

Several projects are under way or planned. For example, a clearinghouse of information on local alliances has been set up and a newsletter to share information and ideas among alliances has begun. Another project will promote the formation of new alliances. Still another involves establishing an inventory and database of programs that offer direct assistance to teachers.

Also in the works is a brochure to promote the idea of "minigrant" programs for schools and teachers and to provide guidelines for establishing and operating such programs. In addition, the coalition is cooperating with NSF in promoting National Science Week. It also is making plans for a national conference on elementary science and technology education, to be held later this year.

Chemical companies and other science and technology-oriented firms have been playing an increasingly important role in furthering the cause, both within business-education partnerships and in independent efforts.

For example, Dow Chemical chairman Robert W. Lundeen also is chairman of Michigan's Partnerships for Education Task Force. Projects Dow has participated in or contributed to include a technology workshop for Detroit public school students and the development of two chemistry shows for presentation at school assemblies. Dow also is encouraging each of its 25 locations to establish award programs for teachers in their communities and provides some funds for that purpose.

In Philadelphia, Theodore A. Burtis, chairman of Sun Co., chairs another local alliance, PRISM (for Philadelphia Renaissance in Science and Mathematics). Current PRISM activities include a science materials center, a science/math clearinghouse, a "teachers in industry program," a minigrants program to support innovative science/math projects, an "urban math collaborative" for secondary math teachers, and a program to attract minority students to engineering careers.

Du Pont notes that it has joined with school districts that serve a number of its major facilities in a program to help send community science teachers to regional and national NSTA meetings. For example, the company has provided grants to cover registration, transportation, and lodging for the teachers chosen by their districts. It also has made $3000 grants to each school district "to implement teacher initiatives arising from their NSTA experiences."

Amoco has made sizable grants to support two new precollege programs. One will provide training for science and math teachers in Chicago's public schools. Another, to the University of Chicago School Mathematics Project, will help underwrite the development of a new, applications-oriented math curriculum for K-12 students.

The American Chemical Society, which has had an office of high school chemistry since 1979, now has authorized a staff position for prehigh school science, according to Sylvia A. Ware, acting manager of precollege programs for ACS. However, that position hasn't yet been filled.

"Chemistry in the Community" (ChemCom), an ACS-developed interdisciplinary science course for 10th graders has progressed to the point that it is now undergoing field testing with more than 3000 students in 13 states. W. Thomas Lippincott, director of the project, notes that both students and teachers seem pleased with the ChemCom approach. Plans for commercial publication are going on, as are plans to revise the materials (following the field tests) and plans to help acquaint chemistry teachers around the country with the structure and nature of ChemCom.

The few examples described in this article are by no means a complete list. Across the country, there are many, many other initiatives under way, involving all levels of government as well as educational institutions, scientific and professional organizations, and private companies. Taken together, they afford considerable comfort—suggesting that even in the absence of a crisis atmosphere, some progress has been made in curing the ills of precollege science and math education. □

# Chemical productivity rose nearly 6% in 1985

Productivity in the chemical industry rose in 1985. Not so surprising, considering the massive layoffs and early retirement programs in the chemical industry in the past year. The increase, however, trailed that for all manufacturing (including the chemical sector). Still, it was ahead of the rise for chemicals in 1984.

Using production data from the Federal Reserve Board and hours of production from the Labor Department, C&EN calculates that productivity (output per production workhour) for chemicals and allied products last year rose 5.9% to an index of 135.6 (1977 = 100). This follows a 4.0% rise in 1984, and an 11% increase in the postrecession year of 1983.

The index for all manufacturing climbed 9.2% to 135.4 from the year before when it rose only 1.5%. In 1983, it increased 6.9%.

Using hourly production wages from the Labor Department, C&EN calculates that unit labor costs (production wages per unit of output) for chemicals and allied products in 1985 fell 1.5% to an index of 132.9. In 1984, this index was up 0.7% following a 4.2% decline in 1983. For all manufacturing, the 1985 index was 123.2, down 3% from 1984, which was up 2.3% from the year before. In 1983, unit labor costs declined 2.7% for all manufacturing.

Although the full year showed moderately good results for the chemical industry, fourth-quarter 1985 productivity figures were mixed. The data show the fourth-quarter chemicals and allied products index amounted to 137.6, an increase of 6.7% from the year before, but up only 0.3% from the third quarter. In the third quarter, the index showed an annual increase of 6.0% and a quarter-to-quarter rise of 2.0%.

For all manufacturing, the index in the fourth quarter was 136.0, up 8.7% from the same period the year before, but down 0.6% from the previous quarter. In the third quarter, the index rose 8.8% for the year and 1.0% for the quarter.

Unit labor costs for chemicals in the fourth quarter fell 2.4% on an annual basis to an index of 133.7, but rose 1.4% from the third quarter. In the third quarter, they were down 1.6% from a year earlier and 0.7% on a quarter-to-quarter basis. For all manufacturing, the index in the fourth quarter amounted to 124.5, a drop of 4.9% from the year-earlier period, but up 1.7% from the third quarter. This follows an annual decline of 4.7% in the third quarter and a quarterly decrease of 0.7% in that period.

*William Storck, New York*

## Productivity was level in fourth quarter as unit labor costs rose . . .

| Indexes, 1977 = 100 | Quarters, 1985 | | | | Quarters, 1984 | | | | Quarters, 1983 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4th | 3rd | 2nd | 1st | 4th | 3rd | 2nd | 1st | 4th | 3rd | 2nd | 1st |
| CHEMICALS AND ALLIED PRODUCTS | | | | | | | | | | | | |
| Production | 128.1 | 127.9 | 126.3 | 126.0 | 123.2 | 124.6 | 123.4 | 120.5 | 121.2 | 119.0 | 113.8 | 108.7 |
| Workhours | 93.1 | 93.2 | 93.9 | 94.7 | 95.6 | 96.3 | 96.0 | 96.2 | 95.1 | 94.2 | 93.7 | 92.6 |
| Productivity[a] | 137.6 | 137.2 | 134.5 | 133.1 | 128.9 | 129.4 | 128.5 | 125.3 | 124.7 | 126.3 | 121.5 | 117.3 |
| Hourly production wages | 183.9 | 180.9 | 178.6 | 177.3 | 176.5 | 173.5 | 171.2 | 169.8 | 168.7 | 165.4 | 163.3 | 161.5 |
| Unit labor costs[b] | 133.7 | 131.8 | 132.8 | 133.2 | 136.9 | 134.0 | 133.2 | 135.5 | 132.5 | 131.0 | 134.5 | 137.7 |
| ALL MANUFACTURING | | | | | | | | | | | | |
| Production | 128.3 | 127.6 | 126.5 | 126.0 | 120.3 | 120.8 | 118.8 | 116.3 | 121.2 | 119.0 | 113.8 | 108.7 |
| Workhours | 94.3 | 93.2 | 93.4 | 94.5 | 96.1 | 96.0 | 96.3 | 95.4 | 92.9 | 86.5 | 87.1 | 84.3 |
| Productivity[a] | 136.0 | 136.9 | 135.5 | 133.3 | 125.1 | 125.8 | 123.3 | 121.9 | 121.7 | 128.0 | 120.4 | 118.7 |
| Hourly production wages | 169.4 | 167.6 | 167.0 | 163.6 | 163.8 | 161.6 | 160.6 | 159.8 | 157.9 | 155.6 | 154.4 | 153.5 |
| Unit labor costs[b] | 124.5 | 122.5 | 123.3 | 122.7 | 131.0 | 128.5 | 130.2 | 131.1 | 129.7 | 121.9 | 128.2 | 129.4 |

## . . . but for the year, productivity increased and costs fell

| | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CHEMICALS & ALLIED PRODUCTS | | | | | | | | | | | |
| Production | 127.1 | 122.9 | 115.7 | 105.6 | 116.0 | 110.0 | 113.3 | 106.3 | 100.0 | 92.0 | 79.3 |
| Workhours | 93.7 | 96.0 | 93.9 | 95.2 | 101.7 | 101.0 | 103.1 | 102.2 | 100.0 | 97.3 | 92.6 |
| Productivity[a] | 135.6 | 128.0 | 123.1 | 110.9 | 114.1 | 110.0 | 109.9 | 104.0 | 100.0 | 94.6 | 85.6 |
| Hourly production wages | 180.2 | 172.7 | 164.8 | 155.0 | 141.8 | 129.2 | [illegible] | 109.2 | 100.0 | 91.9 | 83.8 |
| Unit labor costs[b] | 132.9 | 134.9 | 133.9 | 139.7 | 124.4 | 117.5 | [illegible] | 105.0 | 100.0 | 97.2 | 97.9 |
| ALL MANUFACTURING | | | | | | | | | | | |
| Production | 127.1 | 119.1 | 115.7 | 99.4 | 108.6 | 105.9 | 110.7 | 106.1 | 100.0 | 94.1 | 84.0 |
| Workhours | 93.9 | 96.0 | 87.7 | 97.0 | 97.9 | 98.9 | 106.2 | 104.5 | 100.0 | 96.1 | 90.4 |
| Productivity[a] | 135.4 | 124.0 | 122.2 | 114.3 | 110.9 | 107.1 | 104.2 | 101.5 | 100.0 | 97.9 | 92.9 |
| Hourly production wages | 166.9 | 161.5 | 155.4 | 149.6 | 140.7 | 128.1 | 118.0 | 108.6 | 100.0 | 91.9 | 85.0 |
| Unit labor costs[b] | 123.2 | 130.2 | 127.3 | 130.9 | 126.8 | 116.6 | 113.2 | 107.0 | 100.0 | 93.8 | 91.5 |

a Productivity is output per workhour, calculated by dividing indexes for production by indexes of workhours of production employees. b Unit labor costs are labor costs per unit of output, calculated by dividing indexes for wages by indexes of output per workhour. **Sources:** Department of Labor, Federal Reserve Board, C&EN estimates